AGS Complex Machine Studies

(AGS Studies Report No. 289)

Stopband Correction of the AGS Booster
Integer Coupling (Qx+Qy=9) Correction Data

Study Period: April 1, 11, 23, 1993

Participants: C. Gardner and Y. Shoji

Reported by: Y. Shoji

Machine:

April 01:	User3	10 Turns	Low dB/dt Injection
April 11:	User1	5 Turns	High dB/dt Injection
April 23:	User3	5 Turns	1.7 kG dB/dt=0 Porch

Aim: Correction of the integer coupling sum resonance Qx+Qy=9.

All data points on Qx+Qy=9 correction currents; N(cos9XY) and N(sin9XY) are listed in Table I.

Table I Qx+Qy=9 correction current data list.

date / T (ms)	B (kG)	dB/dt (G/ms)	dRset (cm)	N(cos9XY)	N(sin9XY)	crossing speed (dQ/ms)	residual loss(%) /cross times
last year [Gardner, AGS SR-273]							
	3.6	0	?	290	90		
Apr.01	u3	10turns		Qy=4.6 fix, change Qx			
40	1.62	20	?	10 ± 5	25 ± 5	0.01	9/?
61	2.89	72	?	-120 ±10	240 ±10	?	8/?

Apr.11	u1	5t	Qx,Qy= 4.44,4.62 --> 4.38 4.56				
35	1.80	70	?	130 ±15	-60 ±15	?	29 /?
55	3.34	70	?	190 ±20	-30 ±10	?	38 /?
75	4.74	70	?	275 ±15	20 ±10	?	5 /?
88	5.25	33	?	295 ±10	35 ±10	?	0.6/?
Apr.23	u3	Qy=4.6		All sextupole = 0 A, Dump Bump = OFF			
80	1.7	0	-0.4	-65 ± 5	54 ± 5	0.014	32/?
			0.4	-48 ± 2	39 ± 1		29/?
			1.2	-38 ± 2	32 ± 2		22/?

I B and dB/dt Dependence

B and dB/dt dependence of correction currents; N(cos9XY) and N(sin9XY) were measured on April 11. The data points were fitted with functions;

$$N(\cos 9XY) = Co + Cb\,B + Cbt\,dB/dt$$
$$N(\sin 9XY) = So + Sb\,B + Sbt\,dB/dt\ . \qquad (1)$$

Here Co, Cb, Cbt, So, Sb and Sbt were fitting parameters. The unit of B and dB/dt were kG and G/ms=kG/s, respectively. The result were;

Co =	35 ± 55	So =	-111 ± 45
Cb =	49.2 ± 7.2	Sb =	28.5 ± 6.0
Cbt=	0.04 ± 0.53	Sbt=	-0.11 ± 0.41
X^2 =	0.50	X^2 =	0.79

(2)

The correction currents has off-set term (remanent field) and B term (magnet construction and alignment) but less dB/dt term (eddy current and back-leg windings). The dB/dt term N(cos0XY), correction current for Qx-Qy=0, was also negligibly small after the change of C5 back-leg winding [W. Van Asselt, AGS schedule meeting]. Then we conclude that there are negligibly small skew quadrupole errors which are proportional to dB/dt.

II Dependence on dR

On April 23 dR (momentum change) dependence of N(cos9XY) and N(sin9XY) were measured on the dB/dt=0 porch. The data points, listed in Table I, were fitted with functions;

$$\begin{aligned} N(\cos 9XY) &= Co + Cr\ dRset \\ N(\sin 9XY) &= So + Sr\ dRset. \end{aligned} \qquad (3)$$

The results were:

$$\begin{aligned} Co &= -55.2 \pm 2.4 & So &= 43.7 \pm 1.6 \\ Cr &= 14.8 \pm 2.8 & Sr &= -10.6 \pm 2.5 \\ X^2 &= 1.09 & X^2 &= 1.94 \end{aligned} \qquad (4)$$

The linear fits (3) were not so bad. The results show the existence of dR dependent term, which explains the residual loss of Qx+Qy=9 correction. We need (6n-3)th skew sextupole strings to cancel Cr and Sr.

III Consistency of Each Data Point

We calculated the correction currents from the parameters (2) for the B and dB/dt on April 1 and at the fit (4). We also calculated the correction currents from the parameters (4) for dRset=0.4cm. They are listed and compared with the measured currents in Table II.

Table II Consistency of each data points.

B (kG)	1.62	2.89	1.7
dB/dt (G/ms)	20	72	0
measured on April 1			
N(cos9XY)	10 ± 5	-120 ±10	
N(sin9XY)	25 ± 5	240 ±10	
calculated from (4); dRset=0.4			
N(cos9XY)			-49 ± 3
N(cos9XY)			48 ± 2
calculated from (2)			
N(cos9XY)	115 ±57	180 ±70	84 ±57
N(sin9XY)	-67 ±47	-37 ±57	-63 ±47
change of dB/dt term			
δN(cos9XY)/δ(dB/dt)	-5.3 ±2.9	-4.2 ±1.0	
δN(sin9XY)/δ(dB/dt)	4.6 ±2.4	3.8 ±0.8	

The inconsistency of parameters (2) and data points measured on April 1 is explained by the change of C5 back-leg winding, which might have changed the dB/dt term. The difference between measured and calculated were divided by dB/dt. The results were listed in the bottom of Table II. The data at B=1.62kG, dB/dt=20G/ms and the data at B=2.89kG, dB/dt=70G/ms gave the same values within the errors. And the phase of dB/dt term; δN(sin9XY)/δN(cos9XY), which was the ratio of δN(sin9XY)/δ(dB/dt) and δN(cos9XY)/δ(dB/dt), was

$$\delta N(\sin 9XY)/\delta N(\cos 9XY) = -0.89 \pm 0.29 . \quad (5)$$

This value is close to the calculated phase of C5 back-leg winding;

$$\delta N(\sin 9XY)/\delta N(\cos 9XY) = -0.5 .$$

The change was proportional to dB/dt and was on the phase of C5 back-leg winding.

The inconsistency of parameters (2) and (4) can not be explained. If we assume dRset=10cm two results meet each other. But dRset could not be such a large value. The chromaticities and orbits were not the same for these two cases. But we are not sure whether these could have changed the correction current.